Mimosa: using ontologies for modeling and simulation

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1 Introduction

Modeling is the shared activity for both modeling and simulation, and knowledge representation. At the same time, the objectives of these two domains are not the same and both seem necessary when dealing with modeling highly structured and complex systems. To face the complexity of the systems we are trying to model and to simulate nowadays, the challenge addressed in this paper is to mix both approaches in a common framework. We first describe separately the recent advances made in the modeling and simulation community as well as in the knowledge representation community. We show that, despite the same goal to describe a reality, or at least a part of it, it results in very different, although related concepts. This difference is due to the focus taken by these communities. The first community is centered on dynamics, and the second one on static descriptions. From the analysis of the differences and similarities, we propose an architecture which is being tested in a modeling and simulation platform: Mimosa. The outcome is a formal way to pave the path from conceptual to running models which is sketched in this paper. The achievements and the perspectives are discussed in the conclusion.

2 Modeling and simulation

Modeling and simulation has been primarily used to model dynamical processes, initially with differential equations. In industrial contexts, the theory of control needed more sophisticated representations, essentially by composing transfer functions. This need gave rise to a number of formalisms for structuring modeling which were finally unified within a widely recognized framework called DEVS for Discrete EVent System [8]. DEVS defines a clear operational semantics and proves its closure under composition. However, the manipulation of very complex models called for even more structured modeling paradigm among which object-oriented and multi-agent systems. *Object-oriented modeling* comes from the intuition that the dynamics are usually associated to devices or parts and the overall dynamics arises from the combination of these parts (e.g; mechanical devices, industrial plants, etc.).

Object-oriented modeling is directly related to object-oriented languages in computer-science. However, while object-oriented languages propose the notions of *classes* and *objects* as instances of classes, only the notion of objects is provided in most modeling and simulation systems. In effect, the purpose of modeling is generally focused on the description of one system, or one category of systems to simulate. The classes of the objects constituting the system are usually predefined in the modeling and simulation platform. Finally, the organization, possibly hierarchical, of these objects and their related dynamics are statically determined at modeling time.

3 Knowledge representation and the ontologies

Independently of the modeling and simulation community, Artificial Intelligence (AI) developed the domain of knowledge representation in order to investigate how human beings talk and reason about the reality. Initially based on formal logics, AI moved rapidly towards more structured representations like frames[5] or conceptual graphs[7], gen-

erally called *object-centered representations*. In these representations, one also distinguishes between *concepts* (describing categories of objects by their shared structures) and *instances* as describing the objects in their unicity. The concepts and instances are described by their attributes and relations with, respectively, other concepts or instances. The notions of concept and instance in object-centered representations does not entirely fit the notions of class and object in object-oriented languages. For example, in knowledge representation, an instance is a kind of concept which denotes (describes) an individual while in object-oriented programming, an instance *is* an individual. As a consequence, in object-oriented programming, an instance has a state which evolves independently of the description of the related class. It is not the case in knowledge representation where the notion of state is meaningless because one only describes what is always true about concepts and instances.

The last outcome of the knowledge representation domain, with the advent of the semantic web, is the notion of *ontology*. According to Gruber[4], the meaning of ontology in the context of computer science, however, is "a description of the concepts and relationships that can exist for an agent or a community of agents.". Contemporary ontologies share many structural similarities, regardless of the language in which they are expressed. Most ontologies describe individuals (instances), classes (concepts), attributes, and relations including the generalization.

4 Mixing both: the challenges

If ontologies seem appropriate to describe the world and, then, to provide means for describing categories of objects and systems, they were only recently used for modeling with the aim of building models for simulation for mainly two reasons: (i) the first reason is technical: the ontologies are mostly used to describe the concepts we are talking about, providing the so-called *conceptual models*. The path from conceptual models to simulation is still long. The first step is to map the conceptual model within a, generally object-oriented, programming language, defining the classes. The step further is to instantiate the classes in as many objects as necessary to build what the modeling and simulation community finally calls a model. (ii) the second reason is semantical: as mentioned earlier when comparing knowledge representation and object-oriented programming, the notion of instance does not correspond to the notion of object. For simulation an object has a state because the system evolves, for knowledge representation an instance does not have any state because the whole representation is made for reasoning about a state of the reality, not for evolving it. These obstacles are the challenges we are facing.

5 Our proposal

Mimosa[1] is an extensible modeling and simulation platform ([6]) used to investigate the above mentioned challenges.

A *conceptual model editor* allows the definition of ontologies using a subset of the UML class diagram equivalent to ontology languages like OWL[2] or others. The user can define the concepts, their attributes and their relationships. Because the ontologies must define what is universally true, only information like the cardinality of the attributes and relations, the types of the attributes and the concepts a concept can be related to, are described. Integrity constraints like in data bases are not considered at that stage. A separated dynamical description can be attached to each concept describing the state (distinct from the attributes) and its dynamics using any formalism which can be mapped into DEVS.

A *model editor* manages the instantiation of the conceptual model into a model, using a superset of the UML object diagram. This model is considered as the description of the reality at time 0. A superset of UML is defined because the object diagram in UML is used for illustration and, therefore, is not rich enough. In particular, we must define the actual value of each attribute as well as the actual relations between the objects in the initial situation. Being still at the knowledge representation level, we insist that the object diagram is a description of the reality at the initial time made of instances.

[1] It is the french acronym for "Méthodes Informatiques de MOdélisation et Simulation Agents": computer science methods for agent-based modeling and simulation

Finally, a running model is created by generating the objects in the object-oriented programming sense from the instances, including states which are initialized from the descriptions and which shall evolve by simulation. The *scheduler* is in charge of generating the initial state of the system before running the model.

6 Conclusion

Most of what is described in the previous section has been implemented and is downloadable from [1]. The main remaining step is a closer interoperability with ontological languages. It relies on the possibility to actually load ontologies made with other systems like Protegee as a base for building simulation models. In the other hand, the possibility to export our conceptual models towards ontology-based systems would expand the possibility to manipulate descriptions and models using XML, as well as adding reasoning capabilities.

Finally, the need to integrate the multiplicity of points of view and scales of description for describing complex systems calls for departing from ontologies in the strict sense (i.e. discourse about beings) to go towards "epistemologies": i.e. discourse about points of view on beings, and ways to articulate them. The AGR[3] paradigm within the multi-agent system community is going in this direction.

References

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